Next Generation Internet Program

Bert Hui

Hilarie Orman

Mari Maeda

GOVERNMENT-WIDE NGI GOALS

DARPA

NSF

NIH

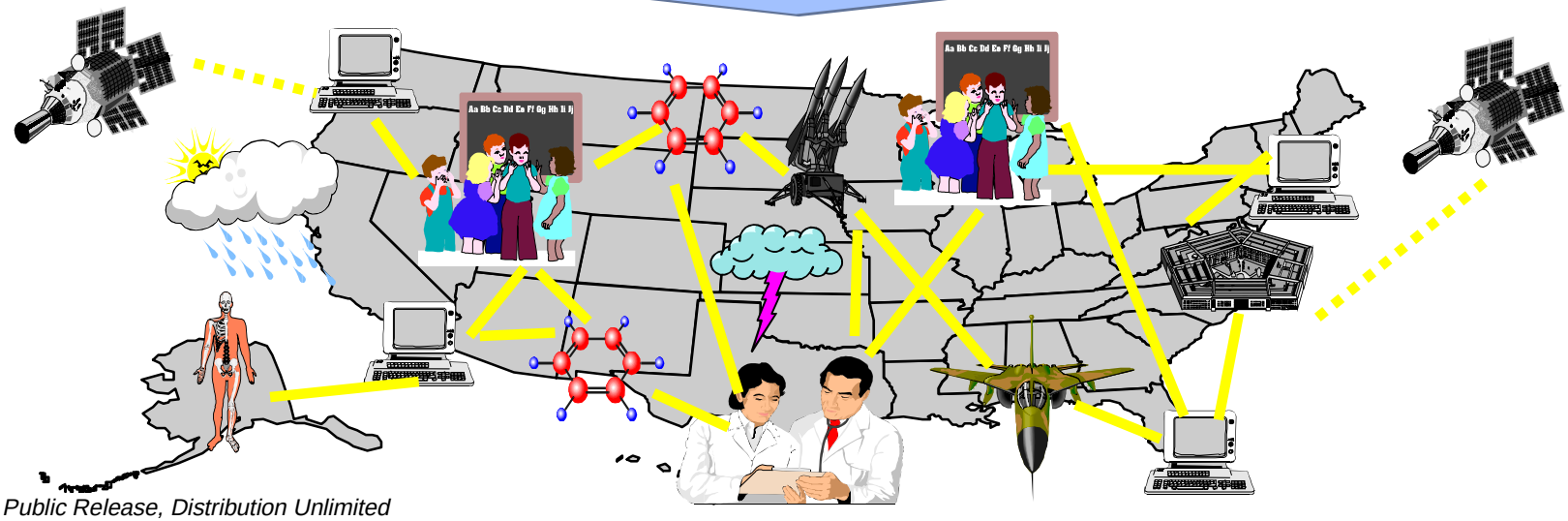
DARPA

NASA

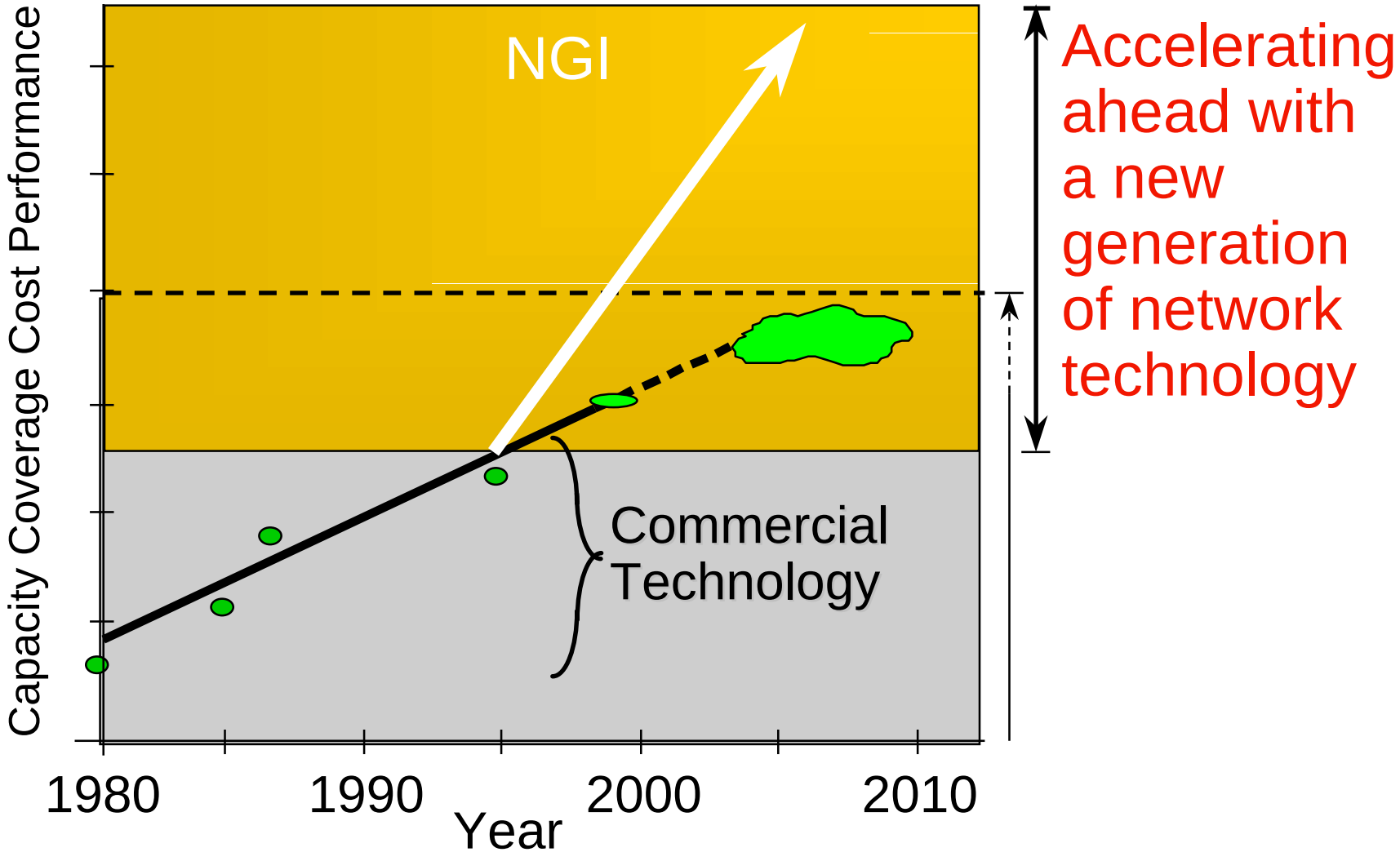
NIST

Goal 1	Goal 2.1	Goal 2.2	Goal 3
Advanced Network Technologies	High Performance Connectivity	Ultra-High Performance Tech.	Revolutionary Applications

Next Generation Internet



NGI: *A NEW STAKE IN THE GROUND*



DARPA'S ROLE IN NGI

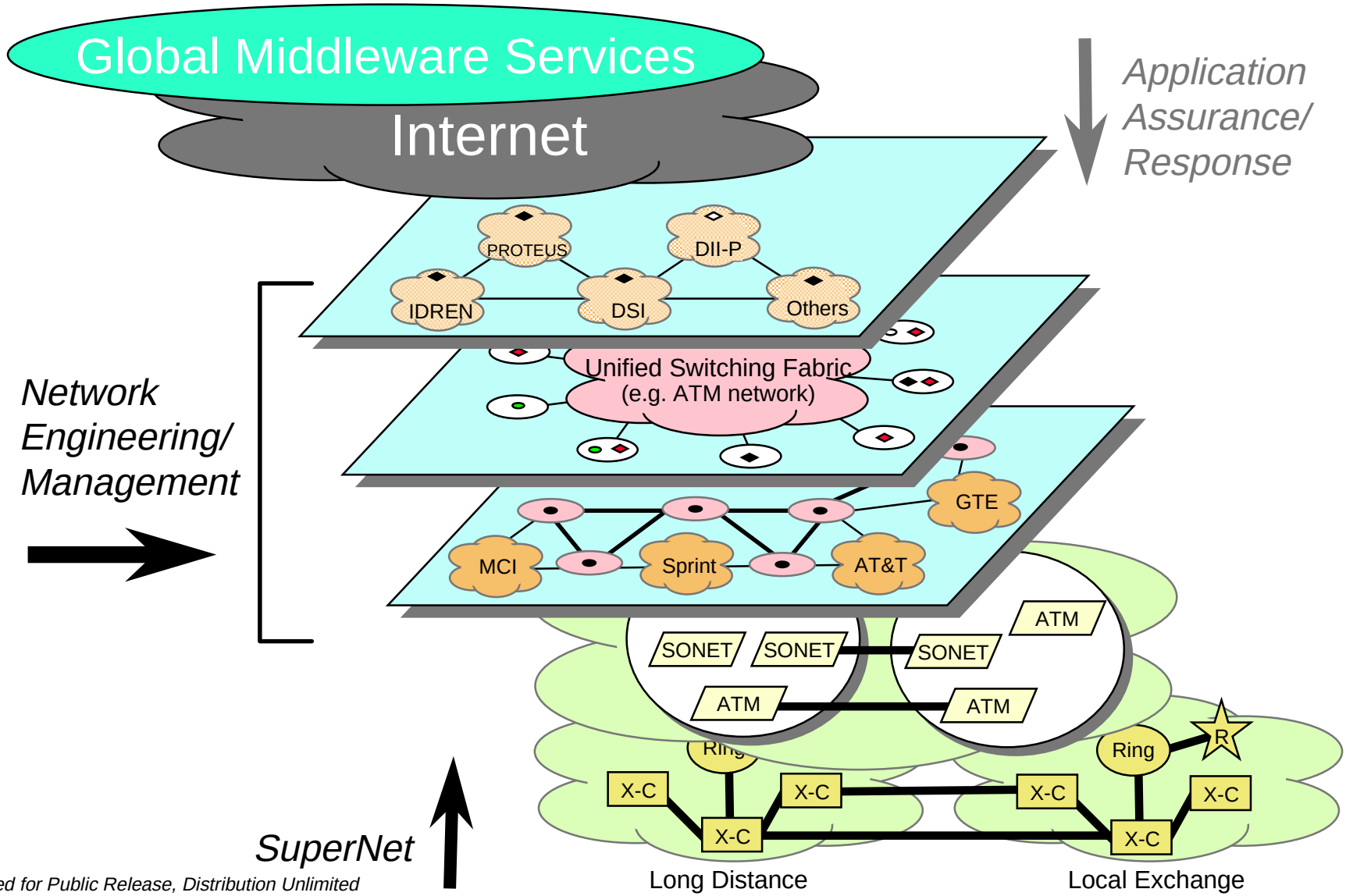
SuperNet: Ultra-high Performance Technology

- Develop technologies for efficient multiplexing / demultiplexing between wide area trunking and end user's Gb/s traffic
- Demonstrate lead user and typical user bandwidth sharing

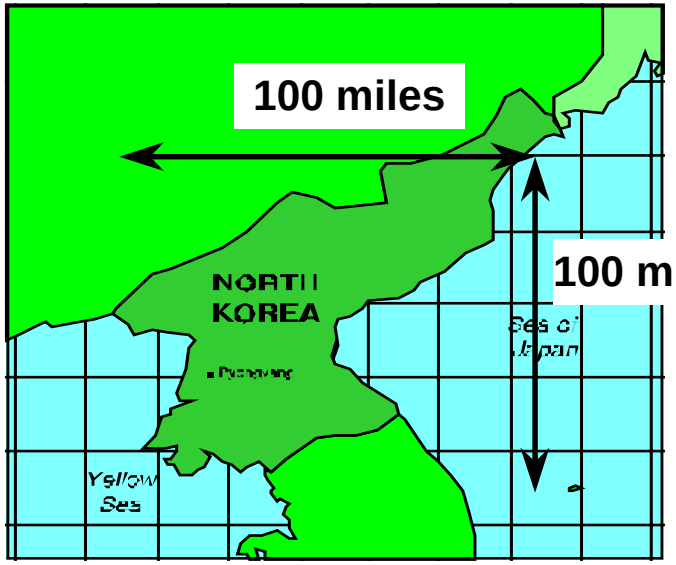
Network Engineering

- Turn today's ad hoc network management approach into an engineering discipline that meets rapidly changing requirements

THE TELECOMMUNICATIONS HIERARCHY



SUPERNET: WHY MORE BANDWIDTH?



Multi-Spectral Sensors

- Radar/SAR
- Infrared
- µ-wave
- Visible

(1 ft x 10 bits)

DOD Information Superiority Requires Terabit Battlefield Surveillance

2.8 Terabit

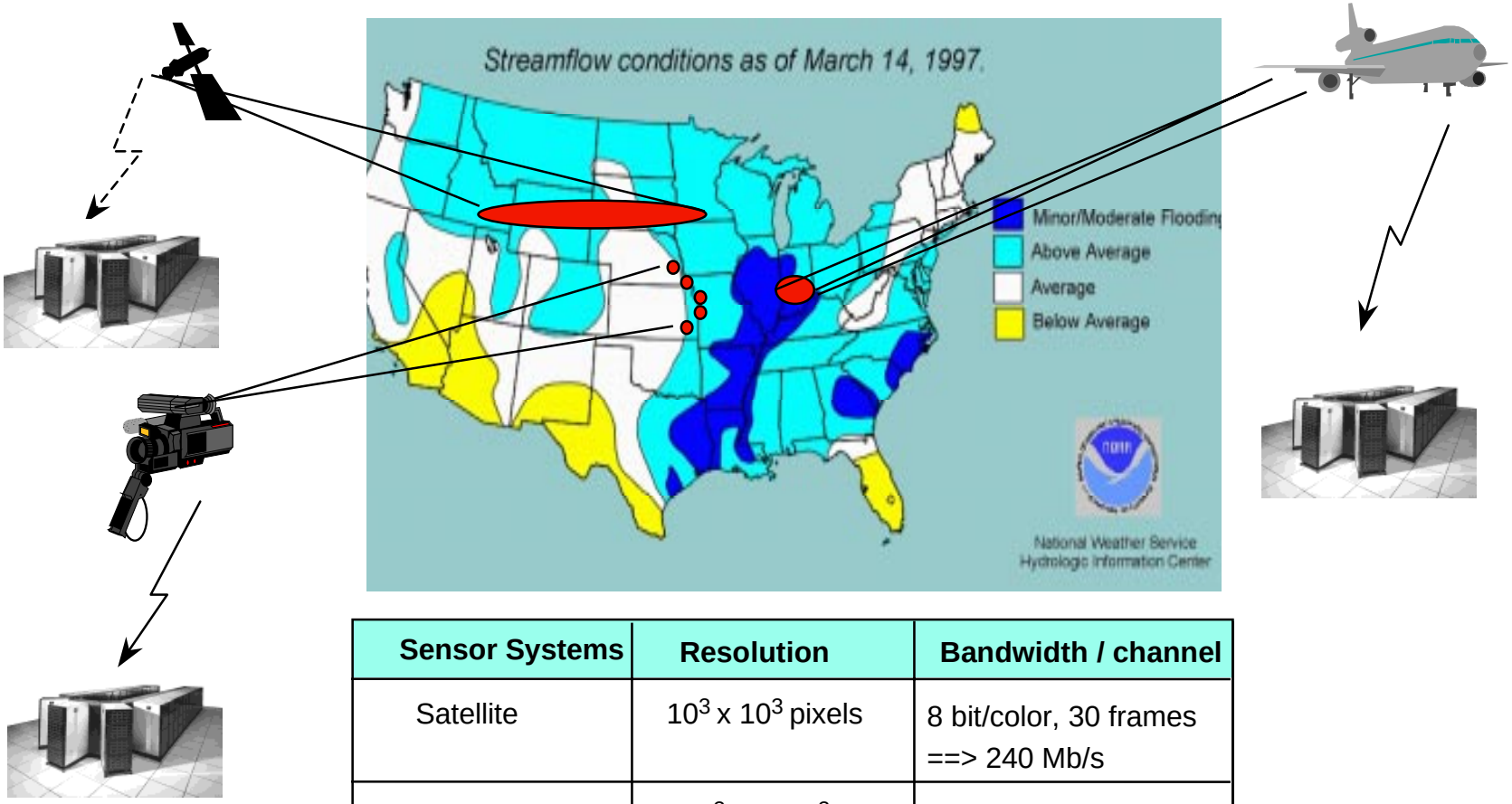
Time to send

17 hours at 45 Mbps

18 minutes at 2.5 Gbps

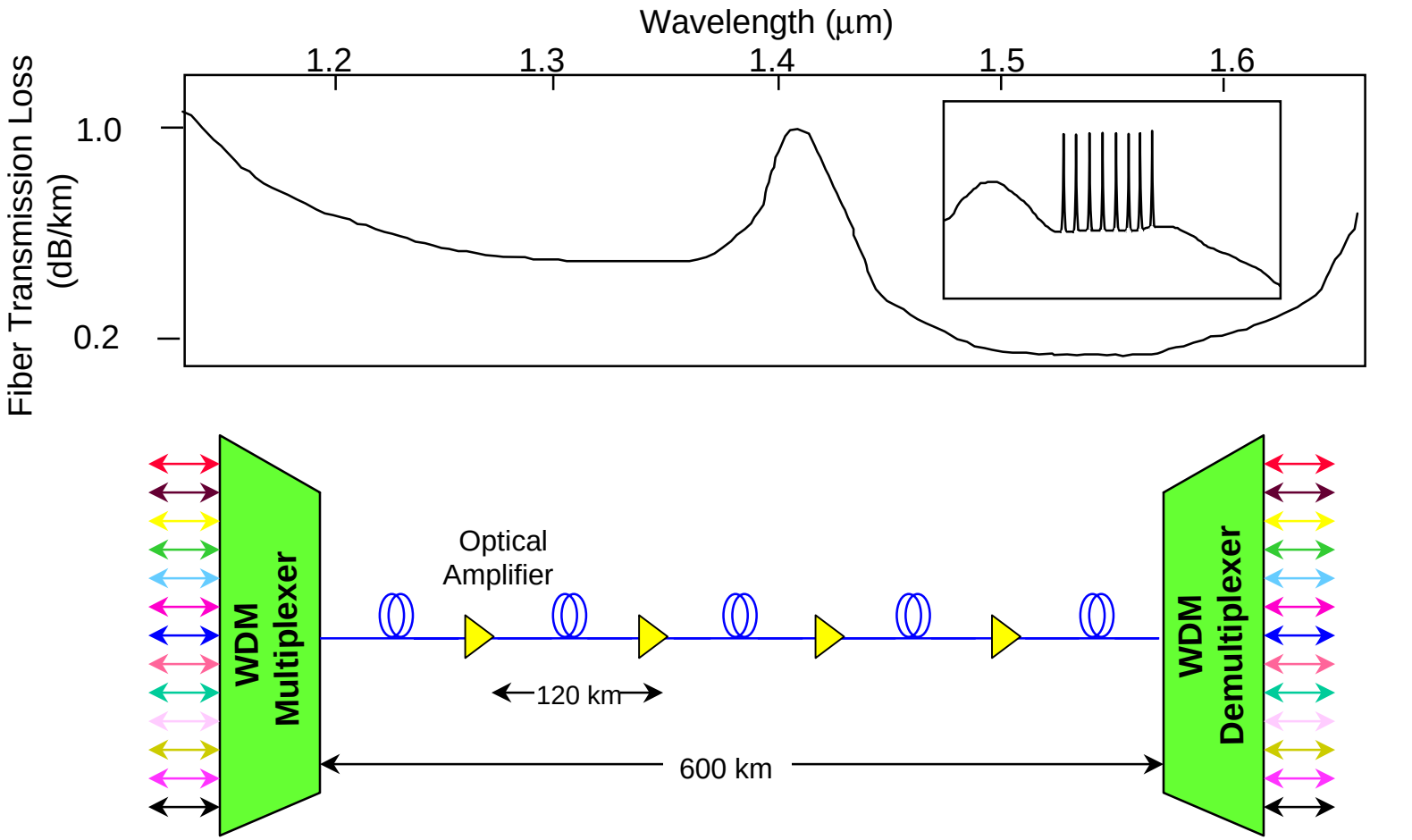
2.8 seconds at SuperNet rate (Tbps)

SUPERNET: TERABIT SURGE CAPACITY FOR CRISIS MANAGEMENT



Sensor Systems	Resolution	Bandwidth / channel
Satellite	10^3 x 10^3 pixels	8 bit/color, 30 frames ==> 240 Mb/s
UAV/video	3.10^3 x $3.\ 10^3$ pixels	8 bit/color, 30 frames ==> 2 Gb/s
radar	1 Ghz bandwidth	Nyquist, dynamic range ==> 20 Gb/s
Cellular	100 Mhz bandwidth	2 Gb/s

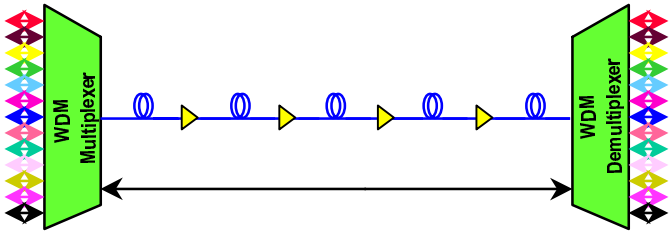
WAVELENGTH DIVISION MULTIPLEXING



- **Savings in equipment and new fiber build costs**
- **Deployment in long haul networks for capacity enhancements**

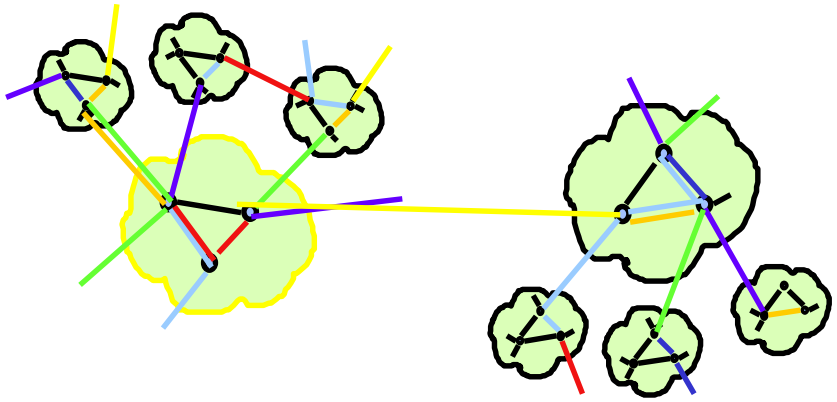
200 Gb/s CAPACITY LASER ARRAY TRANSMITTER

SUPERNET TECHNOLOGIES



- Point to point WDM confined to WAN trunks
- Static or manual configuration
- Low speed end-to-end connectivity

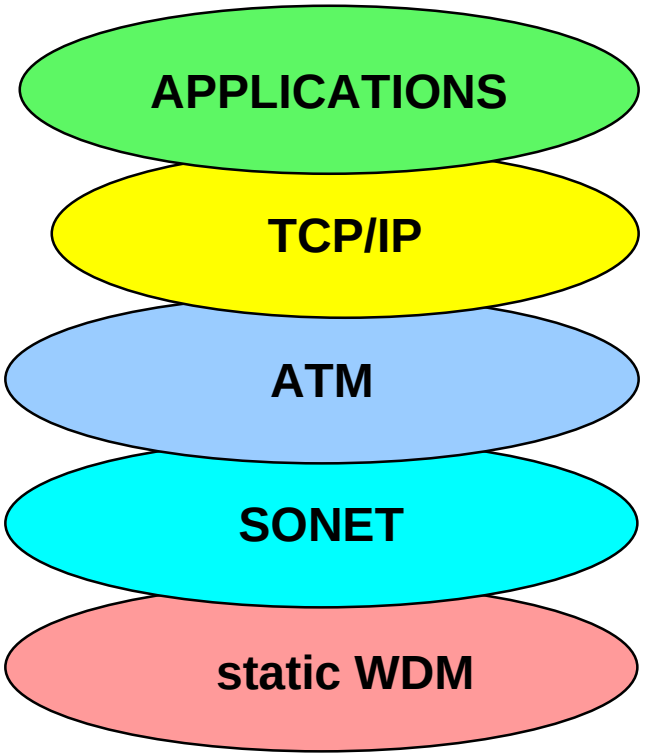
NGI SuperNet



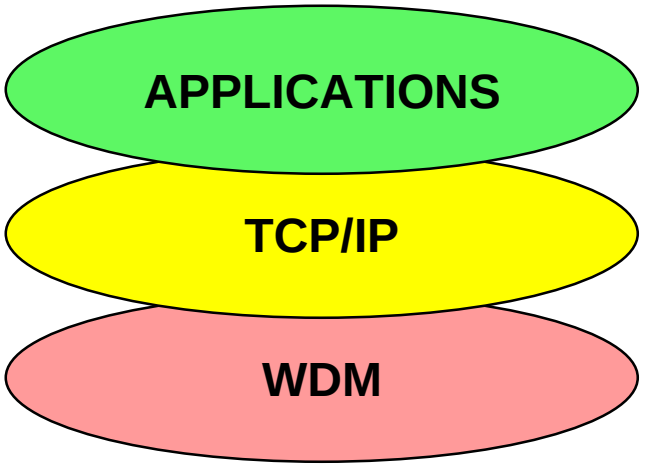
- Wide Area Broadband Networking
- Broadband Local Trunking
- Tb/s Multiplexing and Switching
- Streamlining of Network Layers

SUPERNET – SIMPLIFYING THE NETWORK HIERARCHY

Today's Telecom Infrastructure

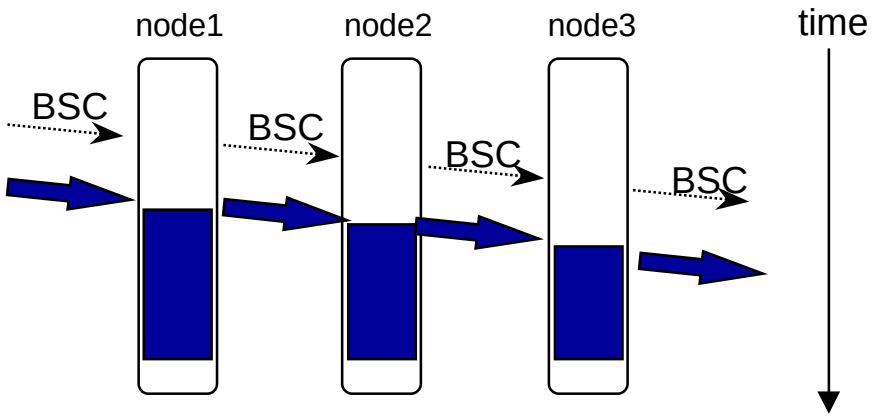


NGI SuperNet

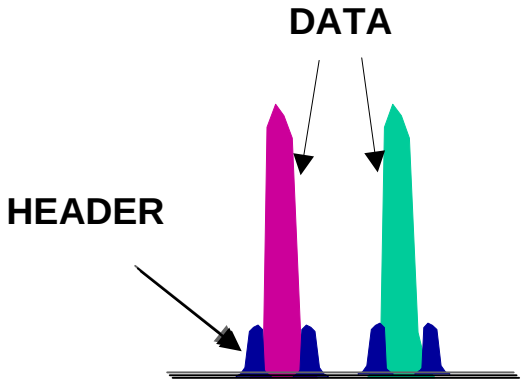


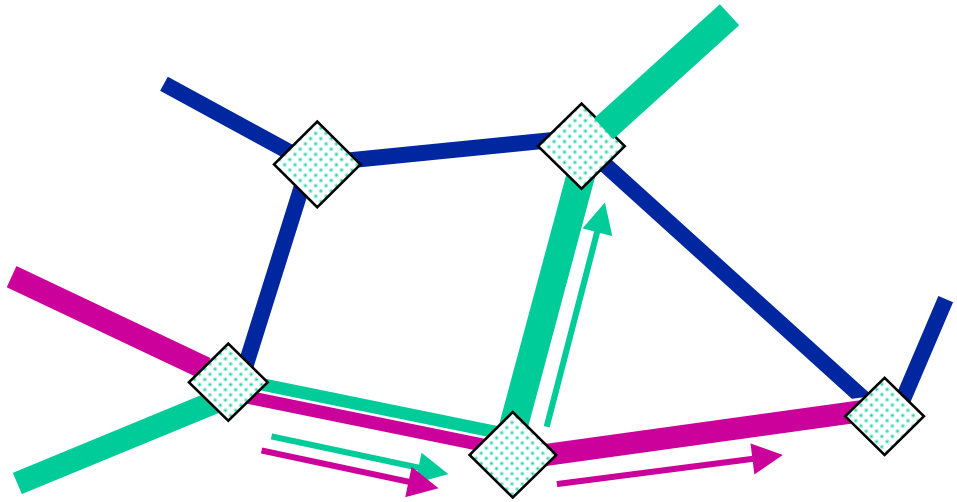
IP OVER WDM

Optical Burst Switch



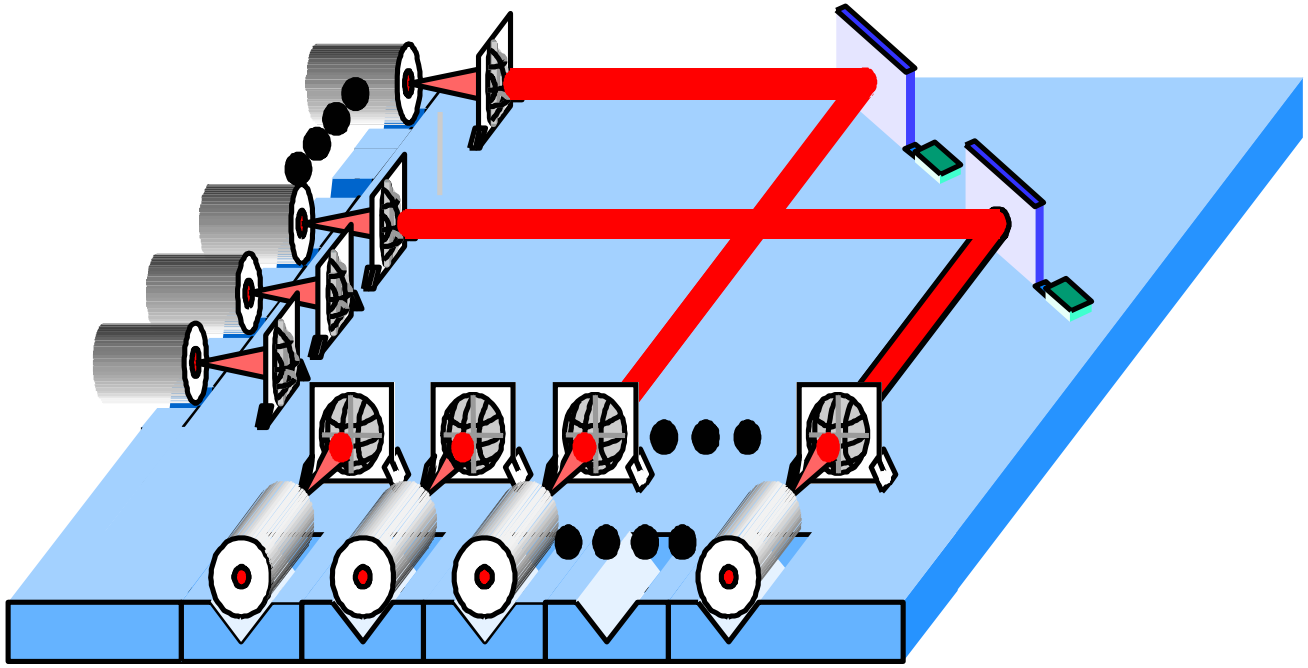
Optical Tag Switching





SUPERNET TECHNOLOGY

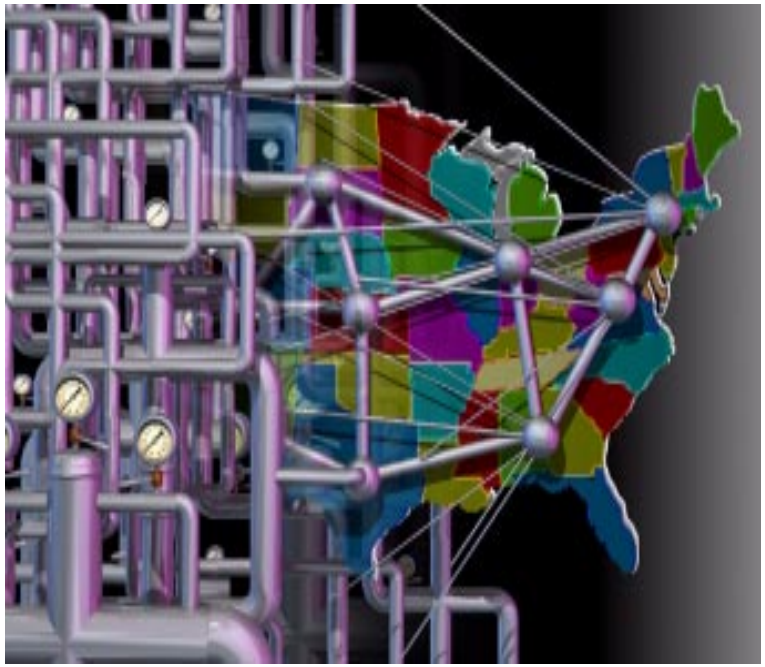
MEMS (Micro-electro-mechanical system) Switch



- Large (32x32) Optical Cross-Connect (OXC) on a single chip of Silicon (< 1 in^2)
- Independent of wavelength, bit rate, protocol, polarization, modulation format, bi-directional, single or multi-mode, with no optical-to-electrical conversion
- > 1000x better performance in speed*power*size

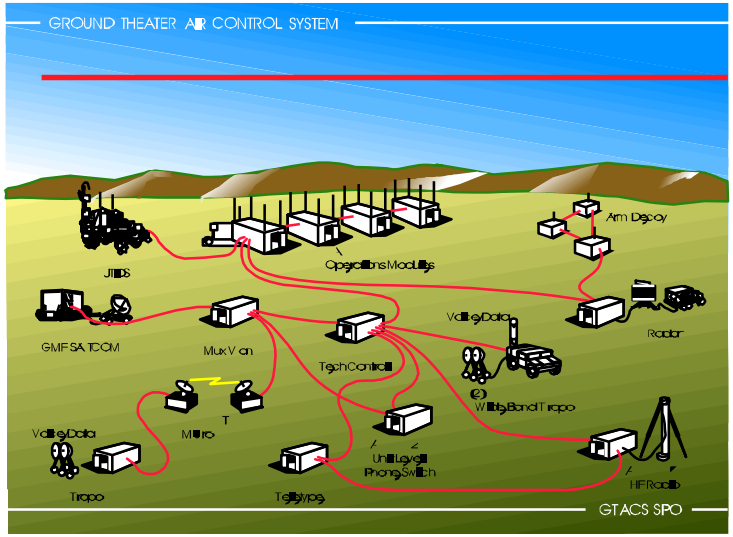
NETWORK ENGINEERING

Rock-Solid Networking Technology for DoD Communication



NGI will respond to rapidly changing DoD communication scenarios ...

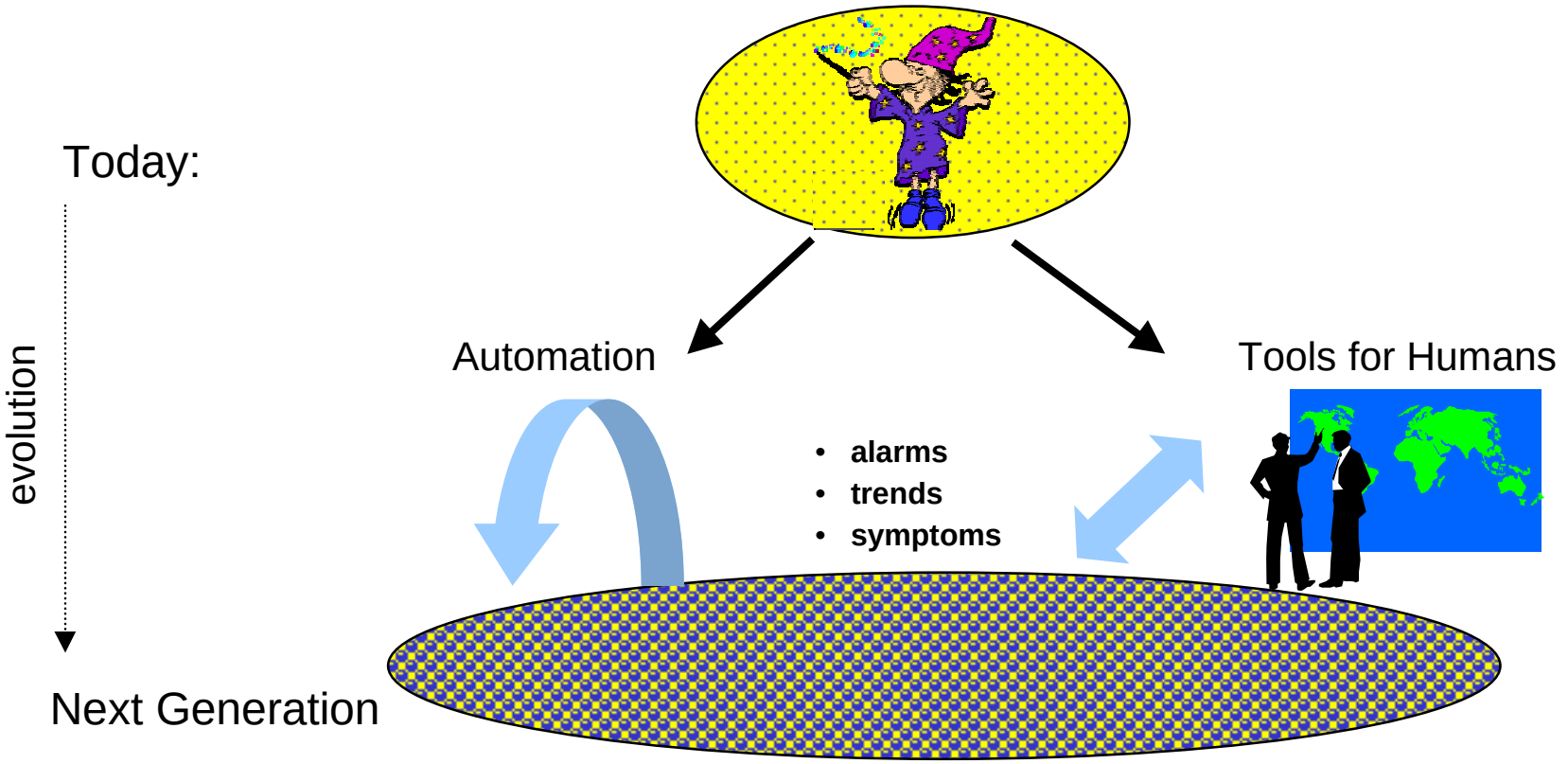
TACTICAL INTERNET CHALLENGES: NETWORK CONFIGURATION



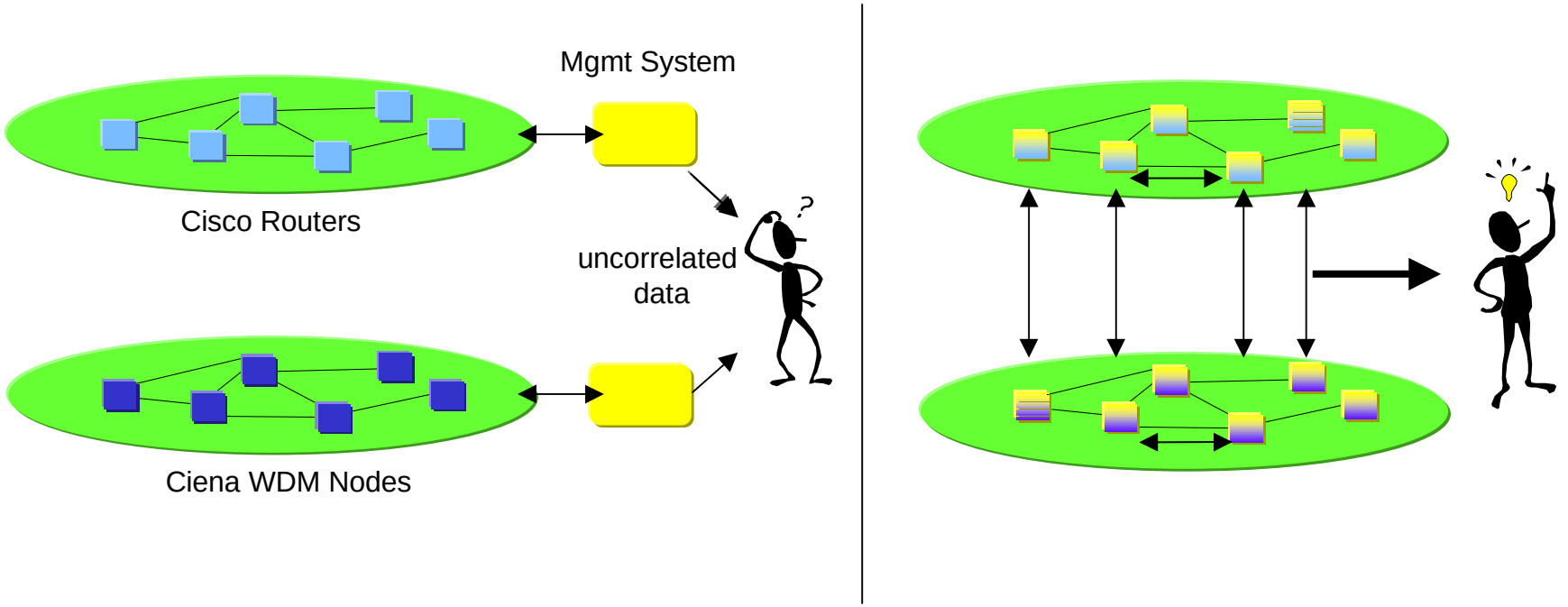
- Networks take time and labor to plan, pack, ship, install, configure
- Only pre-planned configurations are possible
- Over-provisioning increases transport time and reduces readiness

Function	Current	Desired
Network initialization and Topology configuration	> 30 minutes	< 1 minute
Target network size, nodes	100's	100,000
Spectrum planning and radio time-slot management	Days	Real-time
Dynamic resource allocation for applications such as fire control and maneuver control	Not supported	Real-time

NETWORK ENGINEERING



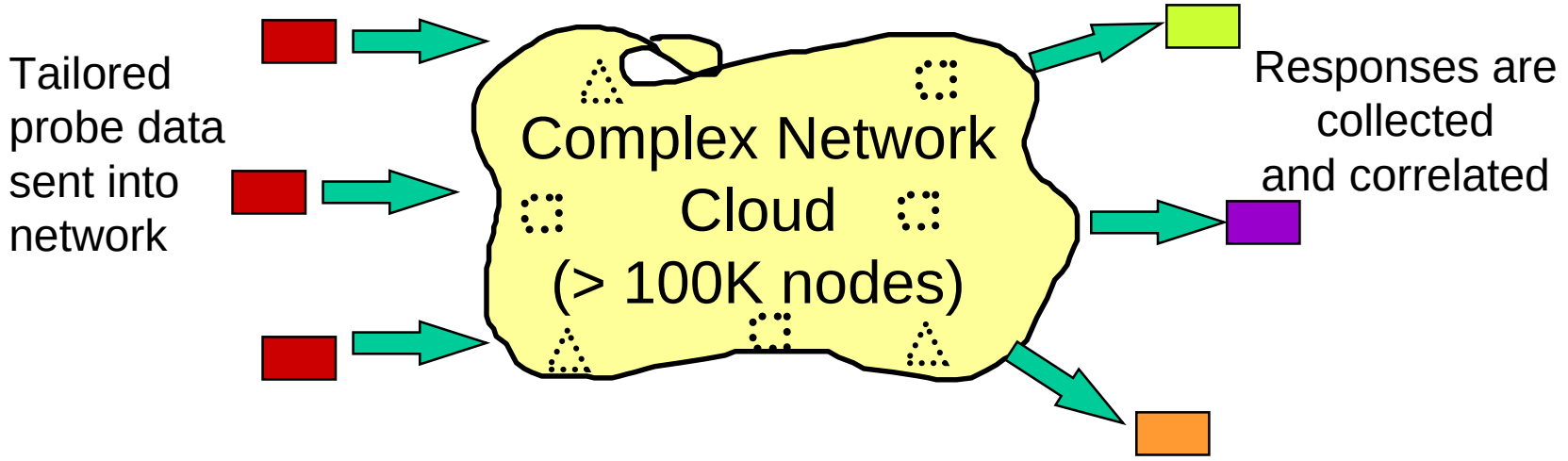
TOWARDS SELF-MANAGEMENT



- **Auto-Discovery**
- **Auto-Configuration**
- **Fault Correlation and Alarm Suppression**
- **Network Restoration**
- **Traffic Management and Adaptation**

REPRESENTATIVE EFFORT: NETWORK ENGINEERING

NETWORK TOMOGRAPHY

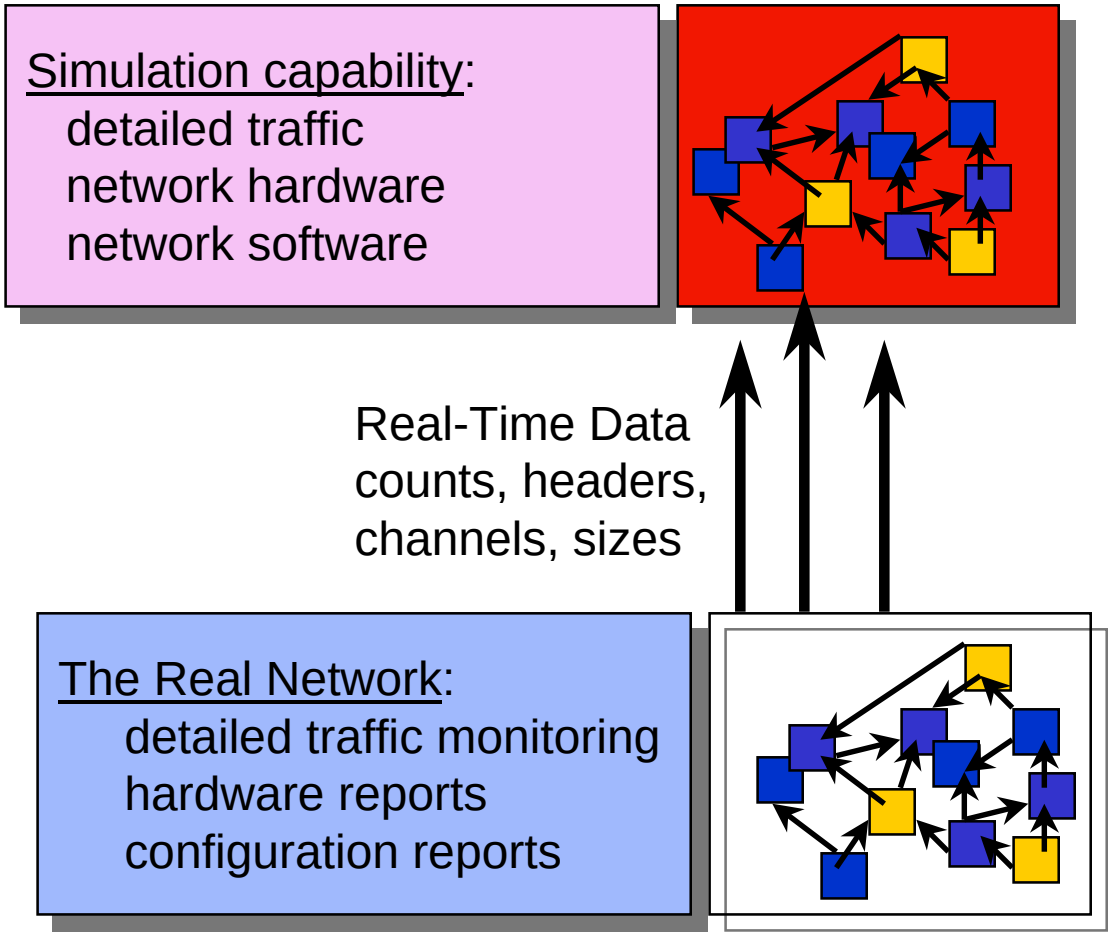


Analysis reveals internal network structure

- Probable Line Errors
- Buffer Capacity
- Hidden Delays
- Intermittent and Periodic Delays

REAL-TIME SIMULATION OF COMPLEX NETWORKS

Predicative and
Validative Correlation



From:

off-line

- yesterday's traffic situation guides today's provisioning
- problems fixed after occurrence

To:

real-time

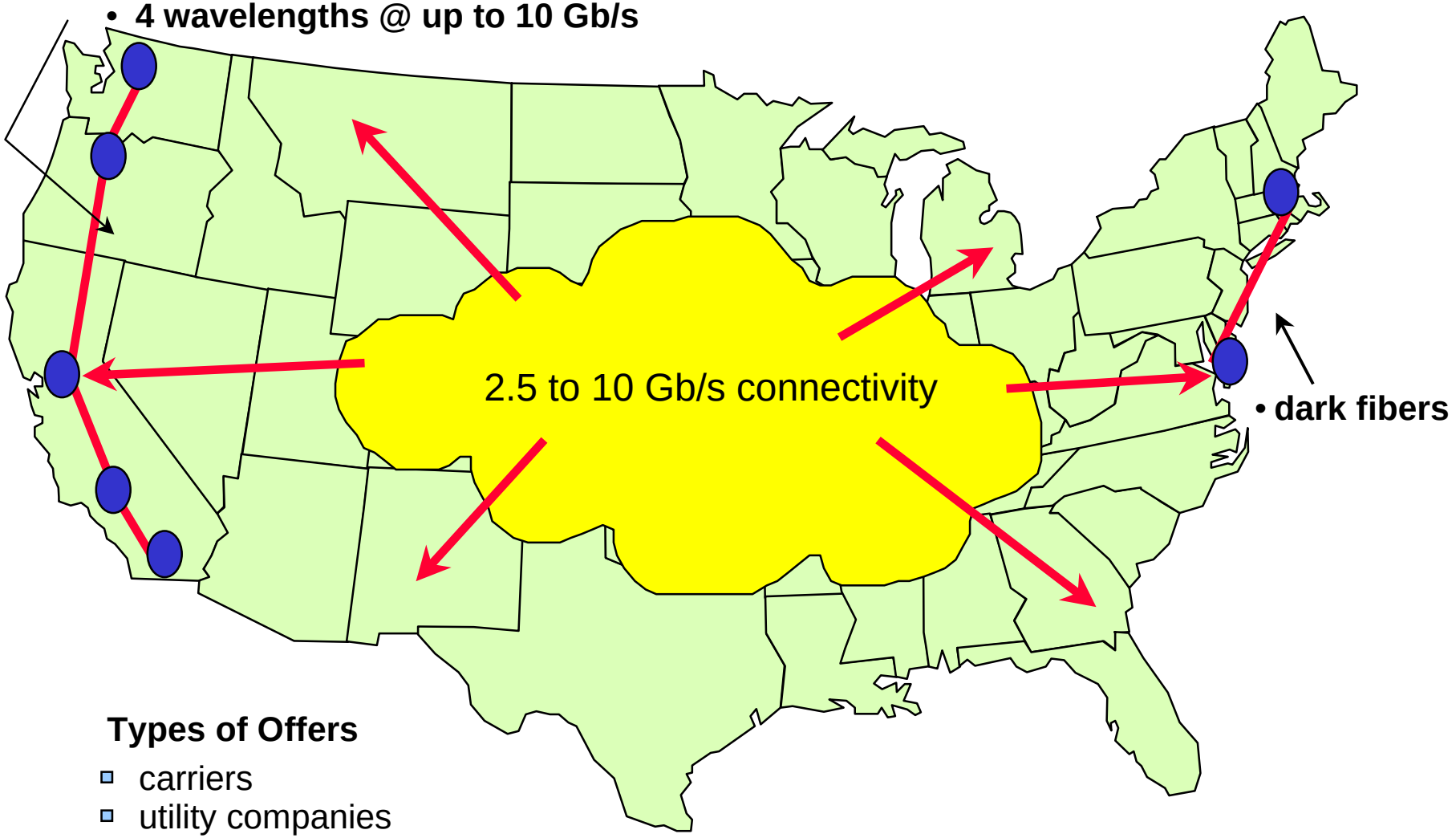
- active probing
- live parameter tuning
- large-scale changes can be checked prior to use

faster than real-time

- adaptive models discover anomalies
- repair validation prior to fielding

SUPERNET TESTBED

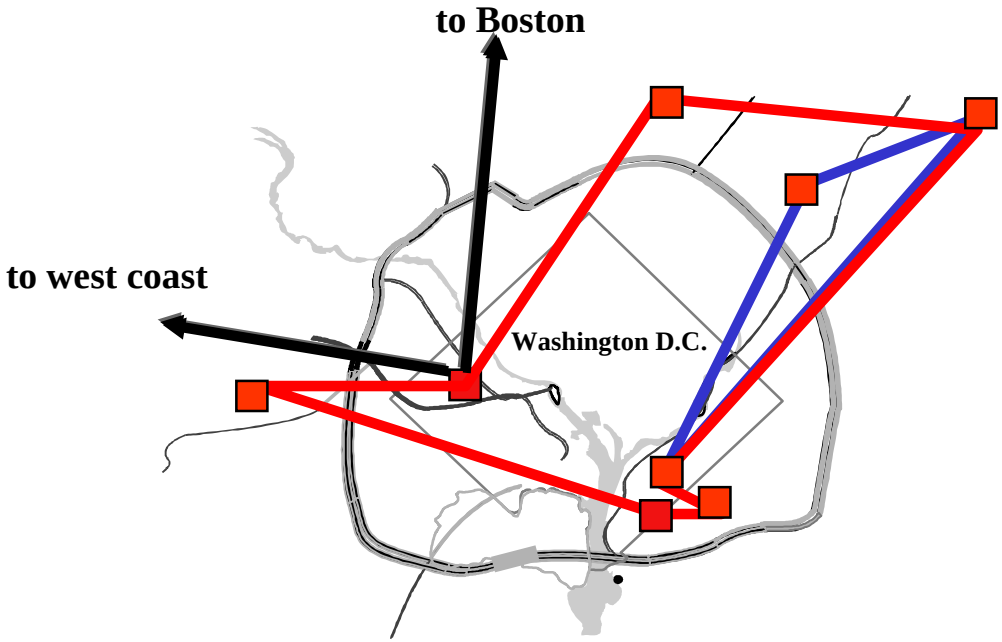
- **4 wavelengths @ up to 10 Gb/s**



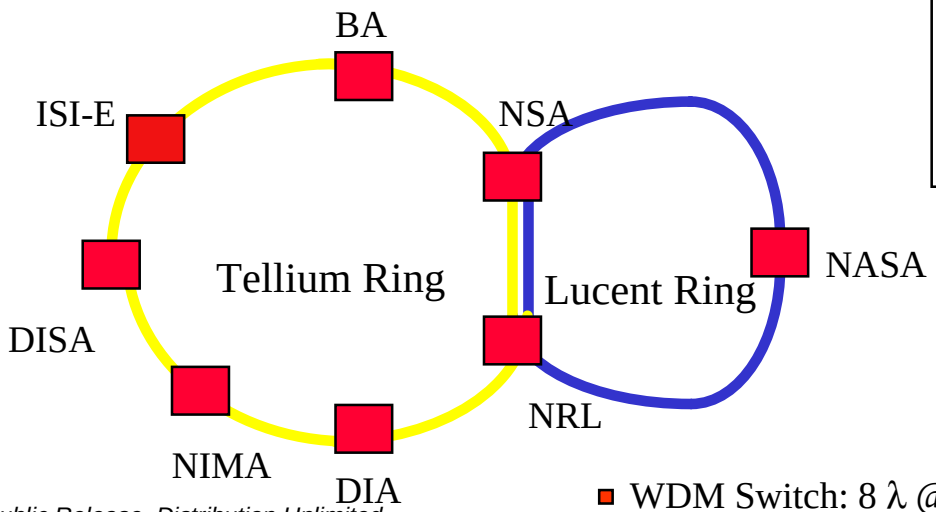
Types of Offers

- carriers
- utility companies
- Internet service providers

ATDNet / MONET TESTBED



- **Limits of Optical Transparency**
- **All-Optical "Just-in-Time" Switching**
- **Optical Self-Healing Rings**
- **Network Management & Control**
- **Multi-Vendor Interoperability**



WDM Switch: 8 λ @2.5 Gb/s per λ, to be installed in 2/99